

Emsian (Early Devonian) Tetracorals (Cnidaria) from Grattai Creek, New South Wales

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The tetracoral species *Phillipsastrea scotti* sp. nov. and *Trapezophyllum grattaiensis* sp. nov. are described from strata assigned to the middle Emsian (*nothoperbonus* to *inversus* conodont zones: Early Devonian) part of the Cunningham Formation at Grattai Creek, west of Mudgee, N.S.W. For comparison with the former, *Phillipsastrea oculoides*, from the Early Devonian (late Pragian or early Emsian) Garra Formation in the Wellington area of N.S.W., is revised on the basis of the type material; new longitudinal thin sections show indisputable horseshoe dissepiments and trabecular fans in this species.

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INTRODUCTION

The two new tetracoral species described here were collected by Martin Scott from the Cunningham Formation on Grattai Creek near Mudgee, N.S.W. during remapping of the Dubbo 1:250 000 geological sheet (Meakin and Morgan 1999). The tetracorals and associated tabulate corals, bryozoans, stromatoporoids, pelmatozoans and comminuted shelly debris are scattered through a mass flow unit at about the middle of the Cunningham Formation; pebbles and cobbles of calcareous, volcanic and metasedimentary rock types occur at this locality in the formation, clearly transported from a shallow water zone into the deepwater environment of the Hill End Trough (HET). The original source of these fossils was probably on the Capertee High to the east, although the direction of transportation of this fossiliferous debris has not been established.

The Grattai Creek fauna described here is important as age-diagnostic macrofossils are rare in strata of the Hill End Trough; biostratigraphic calibration of the HET sequence has been hampered by the lack of such fossils, so any new occurrences

are noteworthy. To put this in perspective, Table 1 shows the stratigraphic positions of important faunas from HET strata. This fauna was first discussed by Percival (1998); further details of the occurrence were given by Meakin and Morgan (1999) and Packham et al. (2001) who provided a full biostratigraphic discussion. Conodonts identified by Percival in Packham et al. (2001) from limestone clasts from the Grattai Creek locality indicated a maximum age within the *nothoperbonus* to *inversus* conodont zones (middle Emsian, late Early Devonian).

As stated above, this fossiliferous horizon lies within the Cunningham Formation, the highest formation of the Hill End Trough sequence. The main locality is on the southern bank of Grattai Creek; material has been collected loose or as clasts in the outcrops. The fossiliferous bed extends for some hundreds of metres along strike, mainly north but also south of the creek, with the maximum development of carbonate clasts in exposures on the southern bank of the creek. The largest coral specimen measured about 10 cm in maximum dimension. It is likely that much loose material was washed away by severe floods in 2000, and little coral material is now available.

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Table 1. Early Devonian rock units of the eastern HET and the Limekilns area. Full details were given by Packham et al. (2001, table 1 and accompanying text). Numbers indicate occurrence of age-diagnostic fossils as follows: 1, this paper; 2, Packham et al. (2001); 3, Talent and Mawson (1999), Rickards and Wright (2001), Wright and Haas (1990); 4, Garratt and Wright (1988); 5, Wright (in prep.).

Age	HET sequence	Limekilns sequence
latest Lochkovian?-late Emsian	Cunningham Fm ^{1, 2}	Limekilns Fm ³
	Merrions Tuff	Merrions Tuff
	Crudine Group	Crudine Group
Lochkovian-Pragian	Waterbeach Fm	Waterbeach Fm
Lochkovian	Turondale Fm ²	Turondale Fm ^{4, 5}
	Cookman Fm	Cookman Fm
latest Silurian	Chesleigh Fm	Chesleigh Fm ²

GEOLOGICAL SETTING OF FAUNAS
DISCUSSED HERE

Palaeogeographic units for the Early Devonian of this part of central-western N.S.W. were defined by Packham (1960, 1968). Two shallow water structures, the Capertee High to the east and the Molong High to the west were separated by the deepwater Hill End Trough (HET). Biostratigraphic control of Devonian strata on the two highs is provided by the abundant fossils that have been collected from shallow water strata there, but Devonian fossils are rare in HET strata. This, combined with the difficulty of establishing lithostratigraphic correlation between strata of the highs and the trough, makes fossils in HET strata most important in establishing correlations and deciphering the evolution of the region. Therefore the Grattai Creek locality, in yielding conodonts and corals, is important as one of the rare fossil localities in the region.

The fossiliferous sequence at Limekilns, N of Bathurst, has been crucial in providing biostratigraphic control for dating the upper part of the HET sequence (Table 1). The oldest fossils from the Limekilns area are the Pridoli (Late Silurian) graptolites from the Chesleigh Formation described in Packham et al. (2001). The oldest Devonian shelly fauna from the HET in the Limekilns area is the brachiopod fauna from the Turondale Formation at the Paling Yards locality just N of Limekilns (see discussion by Packham et al. 2001); study of this fauna is in progress, but Garratt and Wright (1988) asserted that this fauna is earliest Devonian (Lochkovian). In their paper describing the Limekilns Formation trilobite *Paciphacops crawfordae* (assigned to *Echidnops* by

Sandford [2002]), Wright and Haas (1990) concluded the occurrence was Pragian, largely on the basis of the occurrence of the tentaculite *Nowakia sulcata*. However, graptolites from probably low in the Limekilns Formation were identified by Rickards and Wright (2001) as the Lochkovian *Monograptus uniformis*; they pointed out that this determination was anomalous in view of the inferred ages of the Paling Yards shelly fauna from the Turondale Formation (below) and the Limekilns Formation fauna (above). The Limekilns Formation, therefore of presumed Pragian age, is overlain (apparently abruptly) by limestone ('the Jesse Limestone') with a *serotinus* conodont fauna (late Emsian), as well as rich coral (Etheridge 1892; Pedder et al. 1970; Pickett 1972; Wright, unpublished data), stromatoporoid (Webby and Zhen 1993), brachiopod (Wright, unpublished data), trilobite (Chatterton and Wright 1988) and conodont (Talent and Mawson 1999) faunas.

EMSIAN CORAL FAUNAS IN THE REGION

On the Capertee High, Emsian coral faunas are known from several localities, especially near Mudgee. Prolific, largely undescribed coral faunas occur near Mudgee at Mount Frome (Wright 1966, 1981) and in the Sutchers Creek Formation in the Queens Pinch belt (Wright 1966, 1979); both formations have yielded *serotinus* age conodont faunas (Pickett 1978; Wright 1981; McCracken 1990; Talent et al. 2000), although the upper beds of the Mount Frome Limestone are probably Middle Devonian (Pickett 1978). From the Early Devonian Garra Formation (Joplin and Culey 1938) on the

Molong High to the west of the Hill End Trough, Hill (1942b) described the new species *Phillipsastrea oculoides*, from probably Pragian or early Emsian strata (see below). *Phillipsastrea* also occurs in the Mount Frome Limestone, and *Trapezophyllum* occurs with *Phillipsastrea* in the Sutchers Creek Formation; neither genus is yet known from Limekilns.

Elsewhere in the Lachlan Fold Belt, *Trapezophyllum* occurs with *Phillipsastrea* in *serotinus* age beds of the Taemas Formation (Pedder *et al.* 1970) at Wee Jasper, N.S.W, as *Phillipsastrea currani iaspiculensis* Pedder, 1970 and *Sulcorophyllum pavementum* Pedder, 1970. The two genera have been documented from the New England Fold Belt by various authors including Hill (1942a) and Pedder (1968).

SYSTEMATIC PALAEONTOLOGY

In all cases, comments are based on examination of type material as well as original descriptions. Material studied is from the Australian Museum (AM F for rock specimens, AM FT for thin sections), the Mining Museum (MMF) and Museum Victoria. Terminology is that customarily used for fossil corals after Hill (1981); in corals with a well-defined pipe of horseshoes, the internal diameter of the pipe equals the diameter of the tabularium.

Phylum CNIDARIA Hatschek, 1888
Order TETRACORALLIA Haeckel, 1866
Family PHILLIPASTRAEIDAE Hill, 1954 (*pro*
Phillipsastreidae C.F. Roemer, 1883)

Phillipsastrea d'Orbigny, 1849

Type species

Astraea (Siderastrea) hennahi Lonsdale, 1840, p. 697; subsequently designated by Edwards and Haime 1850, p. lxxi (see Lang, Smith and Thomas 1940, p. 99).

Diagnosis

'Astreoid, thamnasterioid, pseudocerioid to partially aphroid coralla. Septa extend variably into tabularium, showing fusiform tabularial boundary, while in dissepimentarium they range from being fully continuous to breaking down into isolated spines. Horseshoe dissepiments vary from intermittent, as in the type species, to a continuous pipe completely surrounding the tabularium' (after McLean 1994a; modified after McLean 1989, p. 239).

Remarks

As noted by many authors, the relationship between *Phillipsastrea* and genera such as *Medusaephyllum* F.A. Roemer, 1855 and *Pachyphyllum* Edwards and Haime, 1850 has been uncertain. Two syntypes of *Medusaephyllum iberdense* F.A. Roemer, 1855 (the type species of *Medusaephyllum*) were located and sectioned by Dr Alan Pedder (McLean 1986, p. 445; 1994a, p. 53), but the species is not yet redescribed and evaluated. *Pachyphyllum* was discussed by McLean (1986, 1989) who recognised it as a separate genus.

The general consensus is that the type species of *Phillipsastrea* probably has good development of the horseshoe pipe but that the horseshoes are largely obscured by coarse trabeculae (McLean 1986; McLean 1994a; Sorauf 1998). McLean's (1994a) generic diagnosis (see above) asserted that the genus could include species with a variable development of horseshoes from intermittent to a continuous pipe. Sorauf (1998) commented extensively on the matter of diagnostic characters of this genus, and specifically stated that the presence of trabecular fans is a more important generic character than horseshoes.

McLean (1994a, pp. 55-6) also indicated that some N.S.W Early Devonian taxa described by Hill and others and originally referred to *Phillipsastrea* (*currani currani* Etheridge, 1892; *currani iaspiculensis* Pedder, 1970; *maculosa* Hill, 1942a; *linearis* Hill, 1942a; *oculoides* Hill, 1942b; *speciosa* Chapman, 1914) appeared to be congeneric and could constitute a new genus.

Phillipsastrea scotti sp. nov. (Figs 1a-d, 2a-d)

Material

Holotype MMF 44852a-b-c, paratypes MMF 34136a-d, MMF 44853a-b.

Locality

Grattai Creek, west of Mudgee, N.S.W. Grid reference 726100E 6382100N, Burrendong 1:50 000 topographic sheet.

Etymology

The species is named for Martin Scott (formerly of the Geological Survey of N.S.W.), collector of the original material.

Diagnosis

An astraeoid species of *Phillipsastrea* with 14-16 major septa almost reaching to axis; corallites

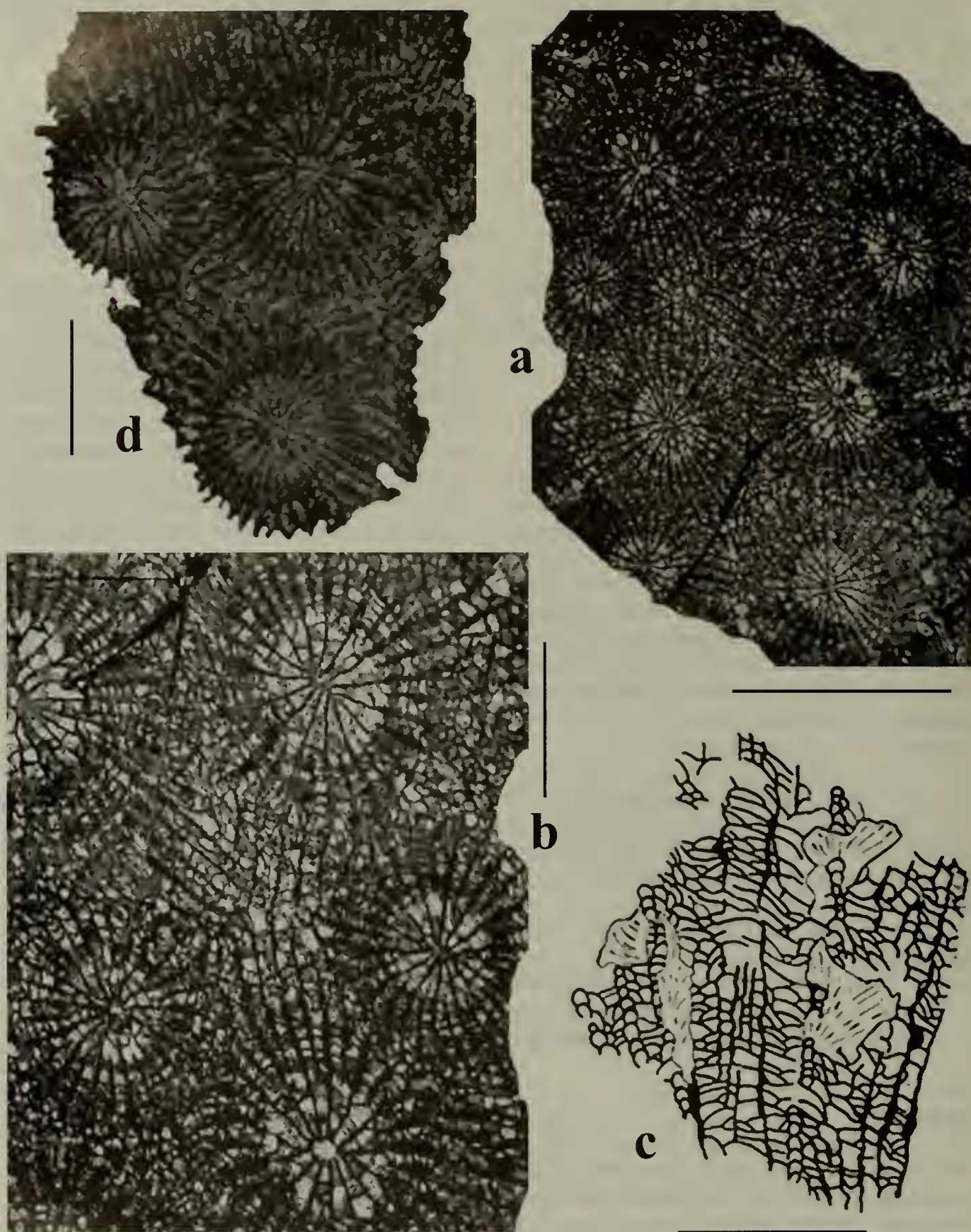


Figure 1a-d. *Phillipsastrea scotti* sp. nov. a-b, transverse views of holotype MMF 44852a. c, longitudinal views, holotype MMF 44852b. d, transverse view, paratype MMF 34136c. Bar scales = 5 mm.

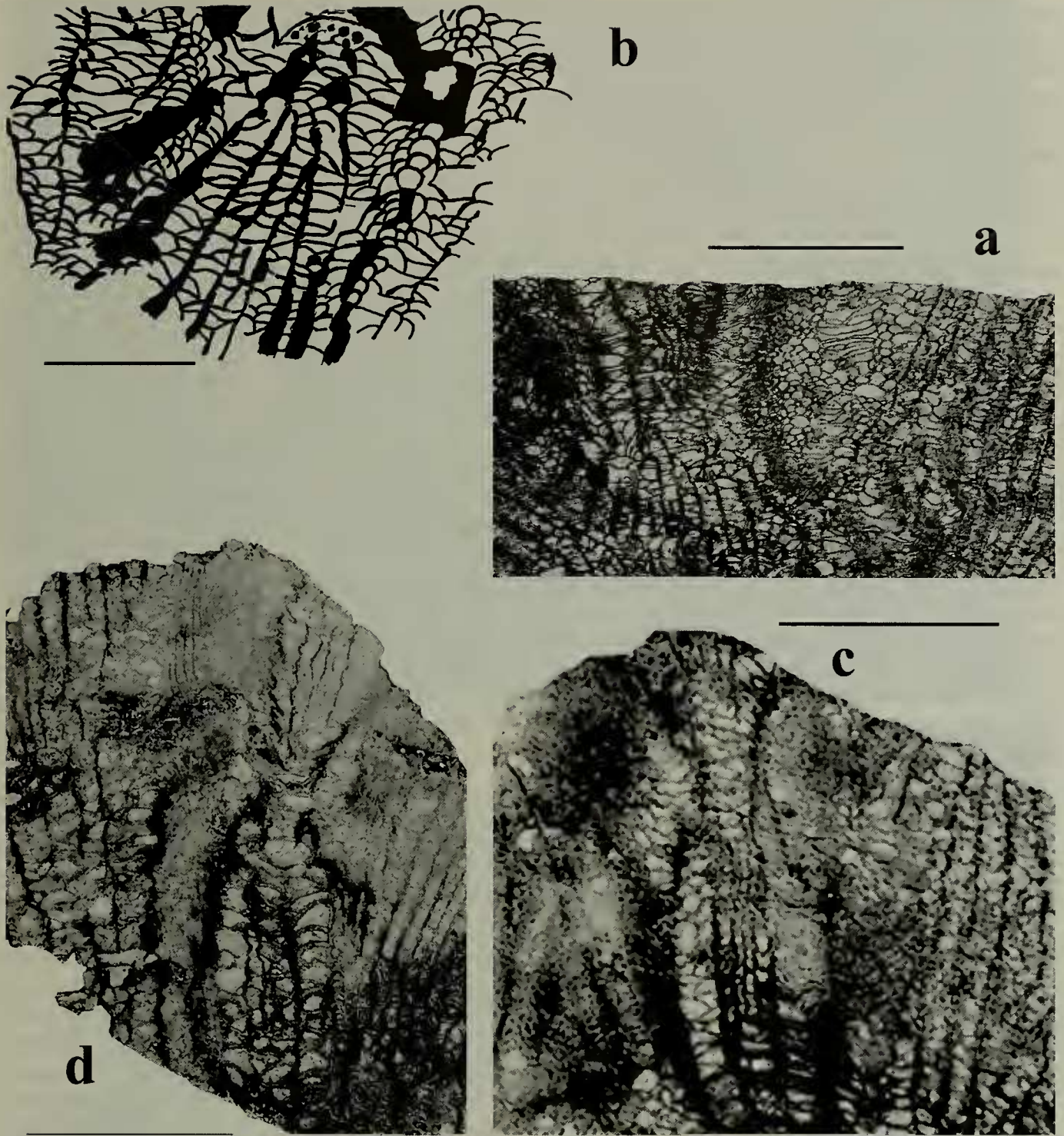


Figure 2a-d. *Phillipsastrea scotti* sp. nov. a-c, longitudinal views, holotype MMF 44852b, holotype MMF 44852c, holotype MMF 44852a, respectively; d, longitudinal view, paratype MMF 44853. Bar scales = 5 mm.

separated by weakly depressed zone of flattish dissepiments outside the horseshoes, seen in transverse section flanking septa. Horseshoe dissepiments form a vertical array of small horseshoes flanked on both sides by small, inclined globose dissepiments; trabecular fans prominent; pipe diameter 4.5 - 5 mm. Tabular floors convex, consisting of weakly convex tabulae, with a gutter where upwardly convex tabellae and globose dissepiments flank the tabulae.

Description

Original colony dimensions unknown, but available material suggests a bun-shaped colony about 75 mm in size. Growth form astraeoid, with little continuity of septa between corallites. Corallite axes from 7.5-13 mm apart, separated by weakly depressed dissepimental area. Pipe diameter about 4.5-5 mm. 14-16 major septa in mature corallites, being equally but slightly withdrawn from axis; minor

septa very short, just penetrating into tabularium. Both orders of septa dilated in typical spindle-form, but thinner inside and outside tabularium. Tabular floors elevated, with convex tabulae flanked by axially inclined tabellae. Pipe well defined in longitudinal and transverse sections; width of horseshoes about 0.5 mm in longitudinal section; globose dissepiments rare to present inside horseshoes, but abundant flattened small sub-horizontal dissepiments occur between corallites forming a weakly depressed coenosteum, and are clear in longitudinal view flanking septa.

Remarks

Of the several N.S.W. Early Devonian species that have been assigned to *Phillipsastrea*, only *P. oculoides* and *P. currani iaspiculensis* (see below for comments) should be compared with the Grattai species. The late Emsian *serotinus* CZ *P. currani* (from the Jesse Limestone Member at Limekilns, N.S.W.) lacks a pipe of horseshoes, and has been discussed by Pedder in Pedder et al. (1970) and McLean (1986, 1989, 1994a, 2005). Two undescribed late Emsian new species of this genus occur in the Mount Frome Limestone near Mudgee, and a further late Emsian new species occurs in the Sutchers Creek Formation at Queens Pinch near Mudgee (Wright, unpublished data). The undescribed species from the Sutchers Creek Formation has a larger pipe and more major septa than *oculoides*, and the Mount Frome Limestone species are distinguished on the basis of the number and detailed nature of septa, and the diameter of the pipe. The Mount Frome, Sutchers Creek and Limekilns occurrences are all from the *serotinus* CZ.

The late Emsian *Phillipsastrea currani iaspiculensis* Pedder, 1970 from the Taemas Formation at Wee Jasper (N.S.W.) resembles *oculoides* in having up to 16 short major septa and discrete septal fragments, but has better developed horseshoes (albeit irregular), flat tabulae, a smaller tabularium and 17-21 vepreculate septa of each order.

Phillipsastrea oculoides Hill, 1942b (see Figure 4 herein) from the Garra Formation near Wellington differs markedly from *P. scotti* in having: 16-19 septa of each order, of which the major septa are strongly dilated and extend only halfway to the axis; septal fragments in the tabularium, and between corallites where septa tend to break into longitudinal fragments; pipe diameter of 4.5-5 mm; corallite axes 9.5-12 mm apart; quite irregular, depressed tabular floors consisting of incomplete globose tabulae flanked by some dissepiments just inside the pipe; strongly depressed dissepiments between tabularia.

The probably Eifelian *Bensonastrea praetor*

Pedder, 1966 from the Timor Limestone in the New England Fold Belt is a close relative of *Phillipsastrea*, but can be distinguished from *P. scotti* on the basis of several attributes, including its larger tabularium, complex dissepimentarium, and 17-21 vepreculate septa of both orders.

Species of this genus from China listed by McLean (1994a) include: the Middle Devonian *ganxiensis* He, 1978 and *yanbianiense* He, 1978; and the Early Devonian *primitiva* Jin and He, 1981; and *producta* Jin and He, 1981. Of these, none closely resembles *P. scotti*: *P. primitiva* is aphroid; *P. primitiva* and *P. yanbianense* have 18-21 x 2 septa; and *P. ganxiensis* appears to have globose dissepiments inside the horseshoes.

Phillipsastrea oculoides Hill, 1942b

(Figs 3a-c)

Synonymy

- 1942b *Phillipsastrea oculoides* Hill, p. 186, pl. VI, fig. 9.
- 1946 *Phillipsastrea oculoides* Hill; Basnett and Colditz, table 1, p. 42.
- 1965b *Phillipsastrea oculoides* Hill 1942; Strusz, p. 565, pl. 73, fig. 7; text-fig. 22.
- 1968 *Phillipsastrea oculoides* Hill; Philip and Pedder, p. 1033.
- 1994a *Phillipsastrea oculoides* Hill 1942c; McLean, p. 56.

Type material

Only the holotype (Figs 3a-c herein) is known (formerly SUGD 5281, now AM F 98541); it consists of three rock pieces and 4 thin sections as follows: AM FT 7896 (oblique LS: Strusz 1965, fig. 22); AM FT 12085 (oblique LS not figured); AM FT 12696 (oblique TS not figured); 12791 (good TS, figured by Hill and Strusz: Fig. 3a herein); and three new longitudinal sections, AM FT 14511-14513 have been prepared (Figs 3b-c herein). Hill's original transverse section was re-figured by Strusz (1965, pl. 73, fig. 7) so is not illustrated here at that scale, but magnified views of several corallites are given; these show the horseshoe dissepiments and trabecular fans (Figs 3b-c).

Locality data

The specimen is from the Garra Formation (Joplin and Culey 1938, Strusz 1965a); locality details given by Hill (1942b, p. 186) are: 'portion 247, parish of Mickety Mulga (sic.), about 6 miles N.W. of Wellington'. The collectors of this specimen, Basnett and Colditz (1946, table 1) showed this

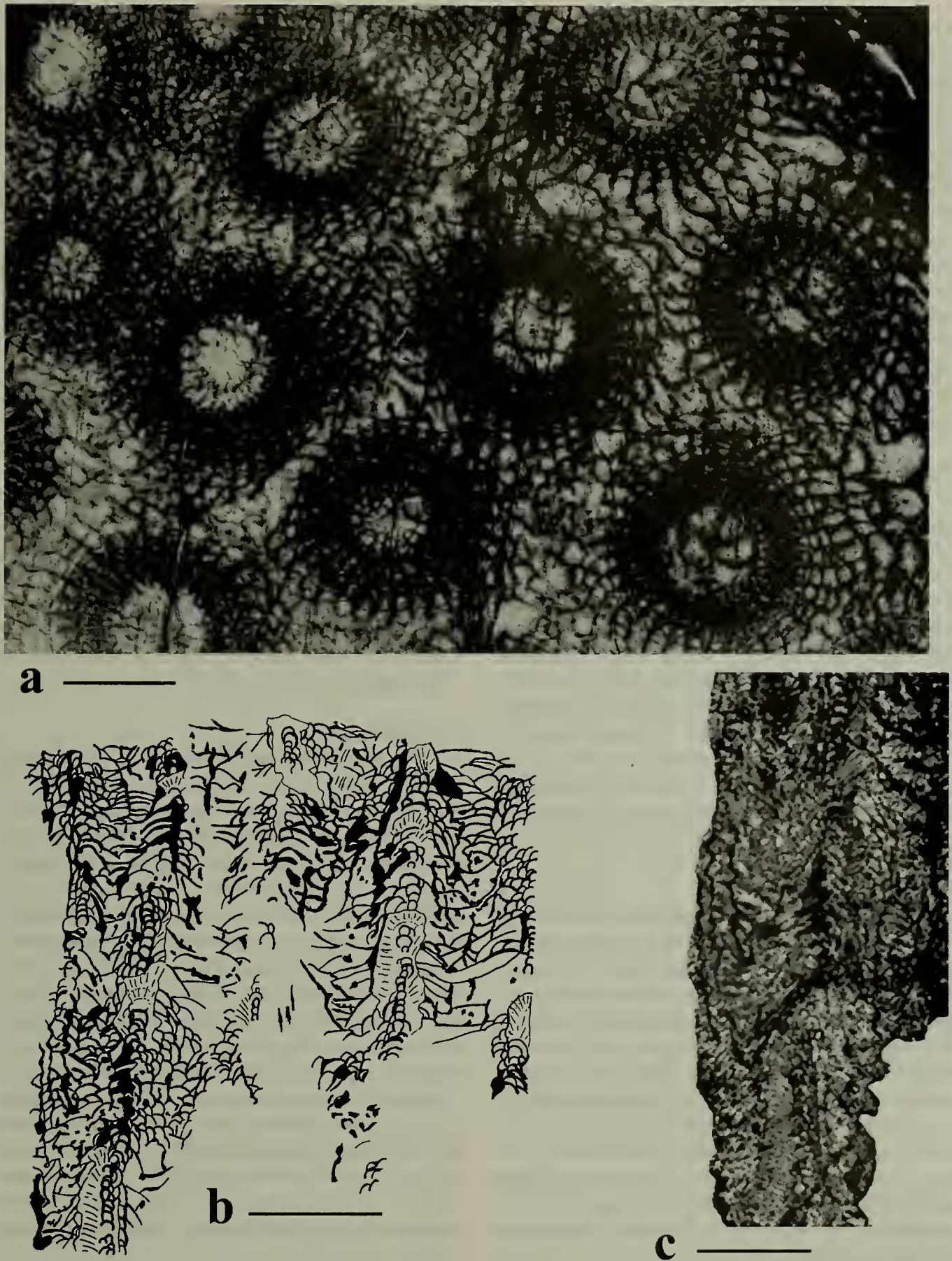


Figure 3a-c. *Phillipsastrea oculoides* Hill, 1942b; holotype AM F98541. a, transverse view , AM FT 12791. b-c, AM FT 14511; b, longitudinal section of a corallite showing good horseshoes and trabecular fans and c, longitudinal view (drawing) of two corallites and coenosteum. Bar scales for (a) and (b) = 5 mm; bar scale for (c) = 2.5 mm.

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locality (their locality IV) also as portion 247. Strusz (1965) gave further details as follows: 'locality MM-10; (parish of Mickety Mulga, county Gordon [sic.]); boundary of portions 60 and 247, c. 500 yds. west of portion 208; grid ref. 1810.9863 (Dubbo); outcrop extends south from fence (portion 60), 200 yds. towards road.' Note that the parish of Micketymulga lies in County Lincoln, not County Gordon. General maps of outcrops of limestones of the Devonian Garra Formation have been provided by Carne and Jones (1919), Basnett and Colditz (1946) and Strusz (1965a, 1965b). Furey-Greig (1995) gave 3 locality citations for *P. oculoides* (grid references 674781 6408371, 675705 6408611, and 675350 6408 750) but clearly one locality yielded the unique specimen of *P. oculoides*.

From what is probably the locality near Wellington that produced the *P. oculoides* coral fauna, Philip and Pedder (1968, p. 1033) gave a faunal list which included the corals *Embolophyllum*, *Tipheophyllum*, *Zelolasma gemmiforme* and *P. oculoides*, and conodonts including *Spathognathodus exiguus* and *Sp. linearis* which, together with *Z. gemmiforme*, suggested to them a late Siegenian-early Emsian age. Philip and Pedder (1968, p. 1033) stated that this was the youngest Garra fauna known to them, but probably older than the Cavan Bluff Limestone at Taemas; by implication, it is younger than the *dehiscens* age conodont fauna from the Garra which they also listed. In current terminology this would make the Garra occurrence of *oculoides* late Pragian or early Emsian (Mawson et al. 1992).

Diagnosis

An astraeoid species of *Phillipsastrea* with 16-19 short major septa which extend about halfway to axis, with minor septa just entering tabularium. Trabecular fans well developed. All septa dilated adjacent to pipe. Septa tend to break into longitudinal fragments both between and within tabularia, and generally do not extend far outside the pipe, but are rarely continuous between corallites. Pipe diameter of 4.5 - 5 mm. Tabular floors depressed, as are dissepiments between corallites, which are separated by 9.5-12 mm. Convex to slightly concave, incomplete tabulae are flanked by tabellae and dissepiments. Horseshoes continuous, width 0.5 - 1.2 mm in longitudinal section. Increase apparently non-parricidal, occurring within coenosteum.

Remarks

This species was described by Hill (1942b) who illustrated only a transverse section of the holotype and Strusz (1965b) who reillustrated the transverse section

with a sketch of an oblique longitudinal section. In order to clarify the true nature of the horseshoes and the tabularium, three new longitudinal sections have been prepared. The species is not redescribed in full here.

Breakdown of septa as seen in the tabularium of *P. oculoides* is variable in *Phillipsastrea* species described by McLean (1994) and Sorauf (1999) but is not known from other Australian Early Devonian *Phillipsastrea*.

Trapezophyllum Etheridge, 1899

Synonymy

- 1899 *Cyathophyllum* (*Trapezophyllum*) Etheridge, p. 31, pl. B, figs 2-4.
1963 *Sulcorphyllum* Pedder, p. 366, text-figs 2a-b.
1968 *Stellatophyllum* Spassky in Bulvanker et al., p. 30.
?1977 *Cystitrapezophyllum* Jia in Jia et al., p. 148.
?1977 *Parasulcorphyllum* Jia in Jia et al., p. 149.

Type species

Cyathophyllum elegantulum Dun, 1897, pp. 83-87, plate III, figs 5-6.

Type material

The type material of this species was incorrectly stated by Fletcher (1971) to be hand specimen GSV 41717 (Sweet collection specimen number 107, formerly held by the Geological Survey of Victoria, now housed in the National Museum, Melbourne, Victoria), from which thin sections AM.2 and AM.3805 (from Sweet collection number 101) were cut. Australian Museum material includes no hand specimens for these thin sections above, but only 3 thin sections: AM.3805 (Dun's LS, the illustrated holotype), and 2 numbered AM.2 (Etheridge's longitudinal and transverse sections). AM.2 (Etheridge's transverse section) and longitudinal section (AM.FT14479: Etheridge's re-numbered longitudinal section) appear to be cut from different rocks. It can be stated that the thin section AM.FT14479 was cut from the rock NMV 41717. Hill (1981, figs 183a-b-c) figured new material of *elegantulum* (UQF31114, UQF54725: neither could be located on July 2, 2007, pers comm. Dr AG. Cook) showing globose dissepiments outside the pipe.

Occurrence

Dun's type species of the genus was based on material from Loyola, Victoria (late Pragian: Cooper 1973; Mawson et al. 1992), and was also

described from the Coopers Creek Limestone by Philip (1965); according to Talent et al. (2000) the Coopers Creek Limestone spans the *sulcatus* and *dehiscens* conodont zones, and is thus late Pragian to early Emsian.

Remarks

Hill (1942a) described two new species from the Sulcor Limestone in the New England Fold Belt of N.S.W. (late Emsian or younger: Mawson et al. 1985), *Trapezophyllum coulteri* and *Prismatophyllum brownae*. The latter species was chosen as type species of *Sulcorphyllum* by Pedder (1963). Pedder (1968) noted that the former species is from the lowest and middle of the three faunas he recognised in the Sulcor Limestone, whereas *brownae* is from the middle fauna.

Pedder in Pedder et al. (1970) described a further species, *Sulcorphyllum pavementum* Pedder, 1970, from Wee Jasper, where it occurs with *P. currani iaspiculensis* Pedder, 1970; *S. pavementum* is also known from rather highly deformed Emsian limestone beds in the Capertee Valley, N.S.W (Wright, unpublished data). Undescribed N.S.W species occur in the Sutchers Creek Formation in the Mudgee district and in the Wellington district (Bunny 1962: probably from the Cunningham Formation).

Sulcorphyllum pavementum was selected as type species of *Parasulcorphyllum* by Jia (1977) but this genus has been regarded as a junior synonym of *Trapezophyllum* by most subsequent authors. Other new genera established by Chinese workers, including *Neotrapezophyllum* Jia & Wang in Jia, 1977; *Cystotrapezophyllum* Cai, 1983; and *Heterotrapezophyllum* Cai, 1983 are in need of further evaluation beyond the scope of this paper, but appear to be junior synonyms of *Trapezophyllum*. At least 16 species, mostly Late Devonian, have been described from China, Germany, Russia and Belgium, but none closely resembles the new Grattai Creek species.

Sulcorphyllum was erected by Pedder (1963) on the premise that it possessed abundant globose dissepiments that occurred outside the pipe of horseshoes; at that time he stated that these are not developed in *Trapezophyllum*. Study by the present author of type, topotype and other material of *T. elegantulum* material has shown that such globose dissepiments do occur outside the pipe in *T. elegantulum* (see also Hill 1981, p. 284, fig. 183-2c), so the use of the occurrence of globose dissepiments outside the pipe in *Sulcorphyllum* cannot be used to distinguish the two genera, which are regarded as synonyms. The same view was expressed by McLean (1989, p. 242) and Sorauf (1998). However,

Pedder (2006, p. 52) maintained that the type species of *Trapezophyllum*, *T. elegantulum*, lacks septal trabeculae and continued to recognise *Sulcorphyllum* as a separate genus. I have studied all available topotype material of this species which certainly does show mostly very fine trabecular structure but trabecular fans are definitely seen in material (Wright, unpublished data) where septal dilation is developed, so I conclude that *Sulcorphyllum* is a subjective junior synonym of *Trapezophyllum*.

I have examined the type material of *Stellatophyllum lateratum* Spasskiy, 1968 which is the type species of this Russian genus. Detailed remarks will be presented elsewhere, but I can assure the reader that this material should be referred to *Trapezophyllum*.

Trapezophyllum grattaiensis sp. nov.

(Fig. 4a-b)

Material

MMF 34138a-c, holotype.

Locality

Grattai Creek, west of Mudgee, N.S.W. Grid reference 726100E 6382100N, Burrendong 1:50 000 topographic sheet.

Etymology

The species is named after the locality on Grattai Creek.

Diagnosis

Trapezophyllum with 12-15 long major septa, reaching to or almost to corallite axis; minor septa just extend into tabularium. Pipe of well-formed, continuous horseshoe dissepiments about 2.5-3 mm in internal diameter; maximum corallite diameter 6 mm; outer rank of dissepiments flat, accessory globose dissepiments outside these absent. Tabulae often complete and slightly convex upwards, supplemented by some globose peripheral tabellae.

Description

Corallum cerioid, originally about 100 mm in size; corallites with 5-7 sides. Wall poorly preserved and thin. Mode of increase unknown. Mature corallites up to 6 mm in diagonal dimension. 12-15 major septa, somewhat wavy and thorny in tabularium, long and thin, with variable dilation over horseshoes; extend almost to corallite axis where they may be in contact. Minor septa about half as long as majors, and just reach into tabularium. Dilation



Figure 4a-b. *Trapezophyllum grattaiensis* sp. nov., holotype. a, MMF 34186b, transverse view ; b, MMF 34186a, longitudinal view. Bar scales = 5 mm.

of septa weakly spindle-form, lesser outside pipe. Pipe about 2.5-3 mm in diameter, well-defined in transverse section; horseshoes continuous and well-formed in longitudinal view, reaching about 0.4 mm in width in longitudinal view; flat dissepiments about 0.5 mm in longitudinal view, about 16 in 5 mm of corallite length. Tabulae mostly complete, and gently convex upwards, supplemented by rare, gently axially inclined, globose tabellae; no dissepiments inside pipe. Only flat dissepiments outside the pipe, with no globose dissepiments.

Remarks

The very distinctive type species, *T. elegantulum*, has been recorded only from Victoria, at the type locality at Loyola (Dun 1897; Etheridge 1899; Hill 1939) and in Gippsland (Philip 1965). It has sporadic globose dissepiments outside the pipe; distant, often complete and sagging to horizontal tabulae; rarely visible minor septa; and short major septa barely entering the tabularium. Hill (1939) stated that there are 10-12 major septa alternating with minor septa; in material I have studied, the range is normally 12-

13 in mature corallites. Minor septa are very slightly shorter than major septa, but are generally discernible, especially where there is skeletal dilation. Tertiary septa as were reported in the type species by Hill (1939, p. 235), but these appear to be limited to very occasional spikes projecting from the wall between minor septa. The type species differs profoundly from the Grattai and all other *Trapezophyllum* species in septal length, the nature of the tabulae, possession of globose dissepiments outside the horseshoe pipe, and in size. Another diminutive and previously overlooked species is *T. tereckense* Spasskiy, 1971; this species will be discussed in detail elsewhere, but it clearly differs markedly from our new species.

Other Australian species of *Trapezophyllum* occur in the Tamworth district (*T. coulteri* Hill, 1942a and *T. brownae* (Hill, 1942a), both from the Sulcor Limestone (Emsian: Pedder 1968, p. 139), and *T. pavementum* from the Taemas area (Pedder et al. 1970)

Trapezophyllum coulteri Hill, 1942a is characterised by having: a corallite diameter of about 4-6 mm and 13-15 septa of each order; pipe

diameter of 2.5-3.5 mm; and an axial space of about 1 mm. The holotype has major septa that are clearly withdrawn from the axis, and are highly dilated over the horseshoes; the tabulae consist of a set of convex axial plates, flanked by convex tabellae; globose dissepiments are rare. *Trapezophyllum grattaiensis* differs in having longer major septa, lesser septal dilation and less regularly convex tabulae.

The holotype of *T. brownae* (SUP 8152, now AM F 133004) was figured by Hill (1981, figs 1823a-b-c) for the first time. It differs clearly from *T. grattaiensis* in having larger dimensions (maximum corallite diameter of 6-7 mm, pipe diameter 2.5-3.5) and 15-18 major septa. The species is further characterised by the wide zone of globose dissepiments outside the horseshoes, being markedly sloping downwards. Hill (1942a, pl. III, figs 4a-b) figured the paratype (formerly SUGD 7246, not 7236 as stated by Hill 1942a, p. 152).

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REFERENCES

- Basnett, E.M. and Colditz, M.J. (1946). General geology of the Wellington district, N.S.W. *Journal and Proceedings of the Royal Society of New South Wales* **79**, 37-47.
- Besprozvannykh, N.I., Dubatolov, V.N., Kravtsov, A.G., Latypov, Yu. Ya. and Spasskiy, N.Ya. (1975). Devonskie rugozy Taymyro-Kolymskoy provintsii. *Trudy Instituta Geologii i Geofiziki, Akademiya Nauk SSSR, Sibirskoe Otdelenie* **228**, 172 pp. (Russian).
- Birenheide, R. (1978). *Rugose Korallen des Devon. Leitfossilien. Begründer von GEORG GÜRICH. 2. völlig neu bearbeitete Auflage* herausgegeben von Prof. Dr. KARL KRÖMMELBEIN, Kiel. Gebrüder Borntraeger, Berlin, Stuttgart. 265 pp. (German).
- Bulvanker, E.Z., Goryanov, V.B., Ivanovskiy, A.B., Spasskiy, N.Ya., Shchukina, V.Ya. (1968). Novye predstaviteli chetyrekh luchevykh korallovykh polipov SSSR. (*New representatives of tetra- radial coral polyps of the USSR*) in Markovskiy, B.P. (ed.) *New taxa of fossil plants and invertebrates of the USSR*, volume 2, part 2, pp. 14-45, Nedra, Moscow (Russian).
- Bunny, M. (1962). *The geology of the parishes of Namina, Wellington and Galwadgere, Wellington, N.S.W.* Unpublished BSc (Hons) thesis, University of Sydney.
- Cai Tu-ci and Zeng Cai-lin (1983). *Atlas of palaeontology of NW China, Xinjiang (Sinkiang)* volume, Part 2, p. 113-216, 684-704.
- Carne, J.E. and Jones, L.J. (1919). The limestone resources of New South Wales. *New South Wales Geological Survey, Mineral Resources* **25**, 411 pp.
- Chapman, F. (1914). Newer Silurian fossils of eastern Victoria. *Records of the Geological Survey of Victoria* **3**, 301-316.
- Chatterton, B.D.E. and Wright, A.J. (1988). Early Devonian trilobites from the Jesse Limestone, New South Wales. *Journal of Paleontology* **62**, 93-103.
- Coen-Aubert, M. (1994). Stratigraphie et systématique des Rugueux de la partie moyenne du Frasnien de Frasnies-les-Couvin (Belgique). *Bulletin de l'Institut des Sciences Naturelles de Belgique (Sciences de la Terre)* **64**, 21-56. (French).
- Cooper, B.J. (1973). Lower Devonian conodonts from Loyola, Victoria. *Proceedings of the Royal Society of Victoria* **86**, 77-84.
- D'Orbigny, A. (1849). *Notes sur des polypiers fossiles*. 12 pp. Victor Masson, Paris.
- Dun, W.S. (1897). Contributions to the Palaeontology of the Upper Silurian rocks of Victoria, based on specimens in the collections of Mr. George Sweet. Part 1. *Proceedings of the Royal Society of Victoria* **10**, 79-90.
- Edwards, H.M. and Haime, J. (1850). A monograph of the British fossil corals. *Palaeontographical Society Monograph*, i-lxxxv, 1-71.
- Etheridge, R. Jr (1892). Descriptions of four Madreporaria Rugosa – species of the genera *Phillipsastraea*, *Heliophyllum*, and *Cyathophyllum* – from the Palaeozoic rocks of N. S. Wales. *Geological Survey of New South Wales, Records* **2**, 165-174.
- Etheridge, R. Jr (1899). Descriptions of new or little-known Victorian Palaeozoic and Mesozoic fossils, No. 1. *Progress Report, Department of Mines, Geological Survey of Victoria* **XI**, 30-36.

EARLY DEVONIAN TETRACORALS

- Fletcher, H.O. (1971). Catalogue of Type Specimens of Fossils in the Australian Museum, Sydney. *Memoir of the Australian Museum* **13**, 1-167.
- Furey-Greig, T. (1995). Checklist of the known fossil localities on the Dubbo 1:250,000 sheet area. *Geological Survey of New South Wales, Unpublished Palaeontological Report 95/01*, 174 pp.
- Garratt, M.J. and Wright, A.J. (1988). Late Silurian to Early Devonian biostratigraphy of southeastern Australia. vol. III, 647-662. In N.J. McMillan, A.F. Embry and D.J. Glass, (eds). Devonian of the World. *Memoir of the Canadian Society of Petroleum Geologists* **14**.
- Haeckel, E. (1866). *Generelle Morphologie der Organismen*. 2, Allgemeine Entwicklungsgeschichte der Organismen. G. Reimer, Berlin.
- Hatschek, B. (1888-1891). *Lehrbuch der Zoologie, eine morphologische Übersicht des Thierreiches zur Einführung in das Stadium dieser Wissenschaft*. Gustav Fischer, Jena, Lief 1-3, iv + 432 pp.
- He Yuan-xiang (1978). Subclass Rugosa, pp. 98-179. In Chengdu Institute of Geology and Mineral Resources (ed.) *Atlas of fossils of southwest China. Sichuan volume, Part 1. From Sinian to Devonian*. Geological Publishing House, Beijing, China (Chinese).
- He Jin-yan (1988). Rugosa, pp. 178-195. In Devonian stratigraphy, palaeontology and sedimentary facies of Longmenshan, Sichuan. Chengdu institute of Geology and Mineral Resources and Institute of Geology, Chinese Academy of Geological Sciences (editor), Geological Publishing House, Beijing. 487 pp.
- Hill, D. (1939). The Devonian corals of Lilydale and Loyola, Victoria. *Proceedings of the Royal Society of Victoria* **51**, 219-256.
- Hill, D. (1942a). Devonian rugose corals from the Tamworth district, N.S.W. *Journal and Proceedings of the Royal Society of New South Wales* **76**, 142-164.
- Hill, D. (1942b). Middle Palaeozoic rugose corals from the Wellington district, N.S.W. *Journal and Proceedings of the Royal Society of New South Wales* **76**, 182-189.
- Hill, D. (1981). *Treatise on Invertebrate Paleontology, Part F, Coelenterata, Supplement 1 Rugosa, Tabulata*. Geological Society of America and University of Kansas, Boulder Colorado and Lawrence Kansas. i-xl, + pages F1-378 (volume 1) and pages F379-761 (volume 2).
- Ivanovski, A.V. and Shurygina, M.V. (1980). Reviziya devonskikh rugoz Urala. (Revision of the Devonian rugose corals of the Urals). *Trudy Paleontologicheskogo Instituta, Akademiya Nauk SSSR*, **186**, 64 pp. (Russian).
- Jia Hui-zhen (1977). Devonian rugose corals, pp. 112-168. In Geological Scientific Research Institute of Hubei (eds) *Palaeontological Atlas of central and southern China, part 2, Late Palaeozoic*. Geological Publishing House, Beijing (Chinese).
- Jin Shan-yu and He Jin-han (1981). The Devonian rugose corals of Guangxi, their sequence and systematic descriptions. In Bai, S.L., Jin S.Y. and Ning, Z.S. (eds), *The Devonian biostratigraphy of Guangxi and adjacent area*, pp. 109-148, 160-165. Peking University Press, Beijing, China (Chinese).
- Joplin, G.A. and Culey, A.G. (1938). The geological structure and stratigraphy of the Molong-Manildra district. *Journal and Proceedings of the Royal Society of New South Wales* **71**, 267-281.
- Lakhov, G.V. (1981). Novye vidy kolonial'nykh devonskikh rugoz Novoy Zemli. (New genera of colonial rugose corals from the Devonian of Novaya Zelya). *Zapiski Leningradskogo Gornogo Instituta* **85**, 65-74. (Russian).
- Lang, W.D., Smith, S. and Thomas, H.D. (1940). *Index of Palaeozoic coral genera*. 231 pp. British Museum (Natural History), London.
- Lin Bao-yu and others (1995). *Monograph of Palaeozoic corals. Rugosa and Heterocorallia*. Geological Publishing House, Beijing, China. 778 pp (English summary, pp. 718-756).
- Lonsdale, W. (1840). In Sedgwick, A. and Murchison, R.I., On the physical structure of Devonshire, and on the subdivisions and geological relations of its older stratified deposits, etc. *Geological Society of London, Transactions*, series 2, **5**, 697 pp.
- Mawson, R., Jell, J.S. and Talent, J.A. (1985). Stage boundaries within the Devonian: implications for application to Australian boundaries. *Courier Forschungsinstitut Senckenberg* **75**, 1-16.
- Mawson, R. and Talent, J.A. (1994). The Tamworth Group (mid-Devonian) at Attunga, New South Wales: conodont data and inferred ages. *Courier Forschungsinstitut Senckenberg* **168**, 37-59.
- Talent, J.A., Mawson, R. and Simpson, A.J. (2000). Silurian to Early Carboniferous (Tournaisian) platform-slope sequences in eastern Australia: recent advances in stratigraphic alignments. *Geological Society of Australia Abstracts* **61**, 114-120.
- Mawson, R., Talent, J.A., Brock, G.A. and Engelbreetsen, M.J. (1992). Conodont data in relation to sequences about the Pragian-Emsian boundary (Early Devonian) in south-eastern Australia. *Proceedings of the Royal Society of Victoria* **104**, 23-56.
- McCracken, A. (1990). *Stratigraphy, chronology and regional significance of Devonian allochthonous blocks and debris flows in the vicinity of Queens Pinch, near Mudgee, N.S.W.* Unpublished BSc Honours thesis, Macquarie University, Sydney.
- McLean, R.A. (1986). The rugose coral *Pachyphyllum* Edwards and Haime in the Frasnian of Western Canada. *Current Research, Part B, Geological Survey of Canada, Paper* **86-1B**, 443-455.

- McLean, R.A. (1989). Phillipsastreidae (Rugosa) in the Frasnian of western Canada. *Association of Australasian Palaeontologists, Memoir* **8**, 239-249.
- McLean, R.A. (1994a). Frasnian rugose corals of western Canada. Part 3A: the massive Phillipsastreidae – *Phillipsastrea*, *Chuanbeiphyllum*. *Palaeontographica A*, **320**, 39-76.
- McLean, R.A. (1994b). Frasnian rugose corals of western Canada. Part 3B: the massive Phillipsastreidae – *Pachyphyllum*, *Smithicyathus*, *Frechastrea*. *Palaeontographica A*, **320**, 77-96.
- McLean, R.A. (2005). *Phillipsastreid corals from the Frasnian (Upper Devonian) of western Canada: taxonomy and biostratigraphic significance*. NRC Research Press, Ottawa, Ontario. 109 pp.
- McLean, R.A. and Sorauf, J.E. (1989). The distribution of rugose corals in Frasnian outcrop sequences of North America, pp. 379-396. In N.J. McMillan, A.F. Embry and D.J. Glass, (eds). *Devonian of the World. Memoir of the Canadian Society of Petroleum Geologists* **14**, vol. III.
- Meakin, S. and Morgan, E.A. (compilers) (1999). *Explanatory Notes, Dubbo Geological Sheet, 1:250 000 S1/55-4*. Geological Survey of New South Wales, Sydney and Australian Geological Survey Organisation, Canberra. 504 pp.
- Packham, G.H. (1960). Sedimentary history of part of the Tasman Geosyncline in South Eastern Australia. *Reports of the XXI International Geological Congress*, **2**, 74-83.
- Packham, G.H. (1968). The geology and sedimentary tectonics of the Hill End-Euchareena district, New South Wales. *Proceedings of the Linnean Society of New South Wales* **93**, 111-163.
- Packham, G.H., Percival, I.G., Rickards, R.B. and Wright, A.J. (2001). Late Silurian and Early Devonian biostratigraphy in the Hill End Trough and the Limekilns area, New South Wales. *Alcheringa* **25**, 251-261.
- Pedder, A.E.H. (1963). Two new genera of Devonian tetracorals from Australia. *Proceedings of the Linnean Society of New South Wales* **88**, 364-367.
- Pedder, A.E.H. (1966). The Devonian tetracoral *Haplothecia* and new Australian phacellophyllids. *Proceedings of the Linnean Society of New South Wales* **90**, 181-189.
- Pedder, A.E.H. (1968). The Devonian System of New England, New South Wales, Australia. D.H. Oswald ed., *International Symposium on the Devonian System, Calgary, 1968*, volume 2, 135-142.
- Pedder, A.E.H. (2006). Zoogeographic data from studies of Paleozoic corals from the Alexander terrane, southeastern Alaska and British Columbia. In J.W. Haggart, R.J. Enkin and J.W.H. Monger, eds, *Palaeogeography of the North American Cordillera: Evidence For and Against Large-Scale Displacements. Geological Association of Canada, Special Paper* **46**, pp. 1-48; Appendix A, Systematic Paleontology, pp. 48-57; Appendix C, Zoogeographic data from studies of Paleozoic corals from the Alexander terrane, southeastern Alaska and British Columbia: Biogeographic Database, pages numbered 1-45.
- Pedder, A.E.H., Jackson, J.H. and Philip, G.M. (1970). Lower Devonian biostratigraphy in the Wee Jasper region of New South Wales. *Journal of Paleontology* **44**, 206-251.
- Percival, I.G. (1998). Early Devonian (Pragian-Emsian) faunas from the Cunningham Formation. *Unpublished Palaeontological Report* **98/02**, Geological Survey of New South Wales, 5 pp.
- Philip, G.M. (1965). The palaeontology and stratigraphy of the Siluro-Devonian sediments of the Tyers area, Gippsland, Victoria. *Proceedings of the Royal Society of Victoria* **75**, 123-246.
- Philip, G.M. and Pedder, A.E.H. (1968). Stratigraphical correlation of the principal Devonian limestone sequences of Eastern Australia. D.H. Oswald ed., *International Symposium on the Devonian System, Calgary, 1968*, volume 2, 1025-1041.
- Pickett, J.W. (1967). Untersuchungen der Familie Phillipsastreidae (Zoantharia rugosa). *Senckenbergiana lethaea* **48**, 1-89.
- Pickett, J.W. (1972). Correlation of the Middle Devonian formations of Australia. *Bulletin of the Geological Society of Australia* **18**, 457-66.
- Pickett, J.W. (1978). Conodont faunas from the Mount Frome Limestone (Emsian-Eifelian), New South Wales. *Bulletin of the Bureau of Mineral Resources, Geology and Geophysics (Australia)* **192**, 97-107.
- Rickards, R.B. and Wright, A.J. (2001). Early Devonian graptolites from Limekilns, New South Wales. *Records of the Western Australian Museum, Supplement*, **58**, 122-131.
- Roemer, C.F. (1883). *Lethaea geognostica*, Theil 1: *Lethaea palaeozoica*: Leif. 2, pp. 113-544, E. Schweizerbart'sche, Stuttgart.
- Roemer, F.A. (1855). Beiträge zur geologischen Kenntnis des nordwestlichen Harzegebirges, Dritte abtheilung. *Palaeontographica* **5**, i-iv, 44 pp.
- Sandford, A.C. (2002). Systematics, biostratigraphy and palaeoenvironments of *Echidnops*, a new genus of trilobite from the Late Silurian – Early Devonian of south-eastern Australia. *Memoirs of the Association of Australasian Palaeontologists* **27**, 1-31.
- Sorauf, J.E. (1972). Middle Devonian coral faunas from Washington and Oregon. *Journal of Paleontology* **46**, 426-439.
- Sorauf, J.E. (1998). Frasnian (Upper Devonian) rugose corals from the Lime Creek and Shell Rock Formations of Iowa. *Bulletins of American Paleontology* **113** (355), 159 pp.
- Soshkina, E.D. (1949). Devonian korally Rugosa Urala. (Late Devonian rugose corals from the Urals). *Akademiya Nauk SSSR, Trudy Palaeontologiceskogo Instituta* **15** (4), 162 pp.

EARLY DEVONIAN TETRACORALS

- Soshkina, E.D. (1951). Pozdne-devonskie korally Rugosa Urala, ikh sistematika i evolutsiya. (Late Devonian rugose corals of the Urals, their systematics and evolution). *Akademiya Nauk SSSR, Trudy Paleontologicheskogo Instituta* **34**, 124 pp. (Russian).
- Spasskiy, N. Ya (1968). Zakonomernosti prostranstvenno-vremennogo rasprostraneniya rodov i vodov. (Na primere cetrechlucevykh korallov Devona). (Regularity in the space-time distribution of genera and species [exemplified by Devonian tetradial corals]). *Ezhegodnik vses paleontologicheskii Obschestvo* **18**, 3-14 (Russian).
- Spasskiy, N. Ya in Dubatolov, V.N. and Spasskiy, N. Ya (1971). Devonian corals of the Dzhungar-Balhashkoi province. *Trudy Instituta Geologii i Geofiziki, Siberskoi Otdelenie, Akademiya Nauk SSR* **74**, 5-40, 74-109 (Russian).
- Spasskiy, N. Ya (1977). Devonskie rugozy SSR. (Devonian rugosa of the USSR). *Isdatelstvo Leningradskogo Universiteta, Leningrad*. 344 pp. (Russian).
- Strusz, D.L. (1965a). A note on the stratigraphy of the Devonian Garra Beds of New South Wales. *Journal and Proceedings of the Royal Society of New South Wales* **98**, 85-90.
- Strusz, D.L. (1965b). Disphyllidae and Phacellophyllidae from the Devonian Garra Formation of New South Wales. *Palaeontology* **8**, 518-571.
- Talent, J.A. and Mawson, R. (1999). North-Eastern Molong Arch and Adjacent Hill End Trough (Eastern Australia): Mid-Palaeozoic conodont data and implications. *Abhandlungen der Geologischen Bundesanstalt* **54**, 49-105.
- Webby, B.D. and Zhen, Yong Yi (1993). Lower Devonian stromatoproids from the Jesse Limestone of the Limekilns area, New South Wales. *Alcheringa* **17**, 327-352.
- Wright, A.J. (1966). *Studies in the Devonian of the Mudgee district, N.S.W.* Unpublished PhD thesis, University of Sydney.
- Wright, A.J. (1979). A new Early Devonian solitary 'cystimorph'. *Alcheringa* **3**, 135-40.
- Wright, A.J. (1981). A new phillipsastraeinid tetracoral from the Devonian of New South Wales. *Palaeontology* **24**, 589-608.
- Wright, A.J. and Chatterton B.D.E. (1988). Early Devonian trilobites from the Jesse Limestone, New South Wales. *Journal of Paleontology* **62**, 93-103.
- Wright, A.J. and Haas, W. (1990). A new Early Devonian spinose phacopid trilobite from Limekilns, New South Wales: morphology, affinities, taphonomy and palaeoenvironment. *Records of the Australian Museum* **42**, 137-47.
- Yoh. S.S. (1937). Die Korallenfauna des Mitteldevons aus der Provinz Kuangsi, Süd-China. *Palaeontographica A* **87**, 45-76.
- Yu Changmin and Liao Weihua (1978). Middle Devonian rugose corals of Longdongshui Member, Houershan Formation from Dushan district, Guizhou. *Memoirs of the Nanjing Institute of Geology and Palaeontology* **12**, 107-145 (English summary 145-146).